2011 Base Year State Implementation Plan Emissions Inventory for VOC, NO_x and CO

For Areas of Marginal Non-attainment of the 2008 Ozone NAAQS in Delaware

F I N A L R E P O R T

Submitted to:

U.S. Environmental Protection Agency

Region 3 – Philadelphia, PA

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SECTION 1

2011 OZONE INVENTORY OVERVIEW AND SUMMARY

Introduction

This document contains Delaware's base year emission inventory State Implementation Plan (SIP) revision under the 8-hour ozone National Ambient Air Quality Standard (NAAQS) set forth by US Environmental Protection Agency (EPA) in 2008.

Background and Requirements

Ground-level ozone, one of the principal components of "smog," is a serious air pollutant that harms human health and the environment. High levels of ozone can damage the respiratory system and cause breathing problems, throat irritation, coughing, chest pains, and greater susceptibility to respiratory infection. High levels of ozone also cause serious damage to forests and agricultural crops, resulting in economic losses to logging and farming operations.

In March 2008, the EPA revised the 1997 8-hour ozone NAAQS of 0.08 parts per million (ppm) to 0.075 ppm (73 FR 16436). The 2008 ozone standard of 0.075 ppm is expected to provide better protections of public health and environment. In a final rule of May 2012, the EPA designated 46 areas in the country as nonattainment for the 2008 ozone standard. New Castle County of Delaware was designated as nonattainment as a part of the Philadelphia-Wilmington-Atlantic City Marginal Non-Attainment Area (NAA) (77 FR 30088). Since this marginal NAA is centered by the City of Philadelphia, it is often referred to as "the Philadelphia NAA." In the same final rule, Sussex County of Delaware was designated as a stand-alone nonattainment area, called "Seaford Marginal NAA," and Kent County was in attainment (77 FR 30088). The EPA made the designations of these three counties based on their 2009-2010-2011 design values, and the effective date of the designations were July 20, 2012.

Ozone is generally not directly emitted to the atmosphere. It is formed in the atmosphere by photochemical reactions among volatile organic compounds (VOC), oxides of nitrogen (NO_X), and carbon monoxide (CO) in the presence of sunlight. To facilitate planning, Sections 182(a)(1) and 172(c)(3) of the CAA require all ozone non-attainment areas to establish a comprehensive, accurate, and current inventory of actual emissions from all sources of the relevant pollutant or pollutants in the area by July 20, 2014 (i.e., two years after designation as nonattainment). Delaware has previously been designated nonattainment for ozone under the 1990 1-hour and 1997 8-hour ozone NAAQSs, and has therefore been subject to this emission inventory requirement since 1990. Delaware has developed emission inventories that meet the criterion of CAA 182(a)(1) and 172(c)(3) every three years since 1990, and Delaware's latest comprehensive, accurate inventory of actual emissions from all sources of VOC, NOx and CO in the State covered calendar year 2011.

The purpose of this SIP revision is to establish Delaware's calendar year 2011 emissions inventory, described in this document, as its base year emissions inventory under the 2008 ozone NAAQS.

Responsibilities

The agency with direct responsibility for developing and submitting this SIP document is Delaware Department of Natural Resources and Environmental Control (DNREC), Division of Air Quality (DAQ), under the Division Director, Ali Mirzakhalili, P.E.. The working responsibility for Delaware's air quality SIP planning falls within DAQ's Planning Branch, with Branch Manager Ronald A. Amirikian. David Fees, P.E., managing engineer, is the principal author of this document.

Project Management

The Emission Inventory Development (EID) Program within the Planning Branch of DAQ was responsible for preparing the 2011 Periodic Emission Inventory (PEI) for criteria pollutants to include emissions of VOC, NO_x and CO summarized in this report. Internal planning began in September 2011, with focus on the 2011 point source inventory reporting cycle taking place in March/April of 2012.

The overall project manager was responsible for identifying overall inventory goals, objectives, and deadlines, initiating inventory planning, approving estimation methodologies recommended by staff, reviewing emissions development work, and preparing inventory reports and documentation.

Point Sources

Point sources staff was responsible for the following:

- Identifying point source inventory goals, objectives, and deadlines;
- Establishing the universe of facilities to inventory;
- Overseeing the development of the survey forms and instructions;
- Providing training and guidance to industry representatives;
- Setting up the on-line electronic reporting system and working with DNREC's Office of Information Technology in preparing the on-line reporting capabilities;
- Performing a technical review of emissions data submitted by facilities;
- Working with facility representatives to correct errors;
- Managing the point source inventory database; and
- Overseeing quality control of point sources data.

Non-point and Off-road Sources

Non-point and off-road sources staff was responsible for the following:

- Researching and recommending emission estimation methodologies;
- Defining all simplifying assumptions;
- Obtaining 2011 activity data, current emission factors, and applicable control information
- Using spreadsheets to calculate emissions;

- Downloading and using the EDMS model for developing aircraft emissions;
- Downloading and using the NONROAD model;
- Reviewing emission calculations for accuracy and completeness;
- Preparing report documents; and
- Compiling supporting documentation.

On-road Mobile Sources

On-road mobile sources staff was responsible for the following:

- Downloading the MOVES model;
- Obtaining 2011 vehicle miles traveled (VMT), vehicle registration, and other mobile input data from the Delaware Department of Transportation;
- Obtaining other data for inclusion in the model inputs;
- Preparing the input files for running MOVES;
- Running MOVES and summarizing the model outputs;
- Reviewing emissions for accuracy and completeness;
- Preparing report documents; and
- Compiling supporting documentation.

As is noted in Section 5 of this report, DAQ is utilizing output from EPA's National Emission Inventory (NEI), version 1, run of the MOVES model.

Inventory Planning

Calendar year 2011 is a PEI year as defined by the Air Emissions Reporting Requirements (AERR). The AERR specifies the emissions data for criteria pollutants that are required to be reported to EPA's NEI. A PEI requires the development of emission estimates from all sources within a state or local area for all criteria pollutants and their precursors. As such, the 2011 inventory can provide the necessary data for the 2008 8-hour ozone NAAQS base year inventory.

Inventory Parameters

The inventory parameters defined by the 2011 Ozone Base Year SIP inventory include the following:

- **Inventory year** – 2011;
- **Pollutants** – VOC, NO_x and CO as precursors to ozone;
- **Source coverage** – all sources, including point, non-point, mobile, and non-road sources;
- **Spatial resolution** – county level emissions;
- **Geographic coverage** –New Castle County and Sussex County; and
- **Temporal resolution** – annual and summer season weekday daily emissions.

Data Collection and Management

For all source categories the gathering of local activity data represented a major task spread over many months. For point sources, most facilities reported their emissions through the use of the

State and Local Emission Inventory System (SLEIS) on-line reporting system. Data entered into the on-line system were transferred to a DAQ database for review and correction.

Microsoft Excel® spreadsheets were employed for managing activity data and calculating emissions from stationary non-point sources and some non-road categories. A consistent set of tabs within each source category spreadsheet included activity data, point source data (if applicable, for backouts), emission factors, controls, emission calculations, NEI input formats, and notes on QA/QC procedures.

Emissions for most of the non-road vehicles and equipment categories were calculated using the NONROAD2008a model. Aircraft engine emissions for landing and take-offs at airports in Delaware were calculated using the Federal Aviation Administration's Emissions and Dispersion Modeling System (EDMS), Version 5.1.4.1.

Emissions data were transferred from SLEIS (point sources), from the non-point and non-road spreadsheets, and from the model outputs to staging tables in Microsoft Access® databases. These databases were then converted to XML files via the EIS bridge tool, and then transmitted to the EIS via CDX web client by December 31, 2012 to meet the reporting requirements of the AERR.

Inventory Development

For point sources, DAQ developed a set of criteria to use in establishing the universe of facilities required to report. These criteria are presented in the point source section of this report. Reporting packages were sent to each facility meeting one or more of the reporting criteria. An extensive amount of review and follow up was performed on the point source data submitted by facilities.

For non-point sources, the first main task involved gathering activity data for each source category. In many cases, these data were obtained from Delaware-specific sources. In some cases the activity data were developed through the allocation of a portion of a national activity dataset (i.e., national off-road equipment populations) to Delaware. Basic demographic data were also used for some source categories and are presented in Table 1-1. Once activity data were obtained, spreadsheets were developed to manage the data and combine the activity data with the selected emission factors to obtain uncontrolled emissions. Finally, for those sources where controls applied, emissions were adjusted to account for control efficiency, rule effectiveness, and rule penetration.

Table 1-1. 2011 Demographic Data for New Castle and Sussex Counties

Demographic Parameter	New Castle	Sussex
Population	544,325	200,771
Households	205,500	80,638
Land Area (square miles)	439	950
Annual VMT (million miles)	5,201	2,224

For on-road mobile and off-road equipment, the MOVES and NONROAD models, respectively, were used to develop emissions from these sources. In the use of these models, activity data were

included in the model input files. For any type of data used by the model for which Delaware-specific data did not exist, the model used the system defaults. Details about Delaware-specific and default parameters are discussed in the on-road and non-road sections. The models account for controls, some of which reflect controls specific to Delaware.

Emissions Summary

The following emission summaries present the entire 2011 emission inventory for VOC, NO_x, and CO for New Castle County and Sussex County broken down by source sector. Throughout this document, annual emissions are reported in tons per year (TPY) and summer season weekday daily emissions in tons per day (TPD). The totals may not match the sum of the individual values due to independent rounding.

Table 1-2. 2011 New Castle County Emissions by Source Sector

Source Sector	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	836	2,750	3,649	3.02	12.02	12.32
Non-point	4,882	1,324	3,425	11.39	2.11	2.24
On-road	3,285	7,495	37,489	8.85	20.65	91.58
Non-road	1,989	3,577	20,688	7.04	11.19	79.33
All Sectors	**10,992**	**15,146**	**65,251**	**30.30**	**45.97**	**185.47**

Table 1-3. 2011 Sussex County Emissions by Source Sector

Source Sector	Annual (TPY)			SSWD (TPD)		
	VOC	NO_x	CO	VOC	NO_x	CO
Point	815	2,456	442	4.94	12.10	1.60
Non-point	2,177	478	2,463	5.95	0.86	2.05
On-road	2,974	4,702	28,323	8.86	14.87	78.67
Non-road	2,558	3,045	16,917	8.47	10.02	60.50
All Sectors	**8,524**	**10,681**	**48,145**	**28.22**	**37.85**	**142.82**

SECTION 2

STATIONARY POINT SOURCES

The point source inventory represents facility-specific data for larger stationary sources. Emissions data for all other source categories are reported at the county level. Point sources typically include large industrial, commercial and institutional facilities. Manufacturing facilities, within the industrial sector, comprise the majority of all reporting point sources. The institutional sector includes hospitals, universities, prisons, military bases, landfills, and wastewater treatment plants.

Unlike other source sector emissions which are estimated by DAQ, point source emissions data are submitted to DAQ by the facilities. Emissions are reported at the process level and include both confined (stack) emission points as well as unconfined (fugitive) emission sources. A key aspect of point source data is the inclusion of facility coordinates to accurately allocate emissions spatially within a county for purposes of performing air dispersion modeling.

The planning and execution of the point source inventory was accomplished in the following chronological order:

- Establish the reporting criteria and list of facilities to survey;
- Obtain inventory data from facilities;
- Perform administrative and technical review of data received from facilities;
- Seek resubmissions/corrections from facilities based on data review;
- Perform internal data manipulation (i.e., apply rule effectiveness, remove non-reactive VOCs, create summer season weekday emission values); and
- Prepare inventory data files, report, and supporting documentation.

Since there may be overlap between point sources and stationary non-point source categories, one final activity required of the point source inventory staff is to provide point source back out data where appropriate. Point source back out data includes emissions, throughput, or employees, depending on the non-point source category methodology.

The following criteria were established for defining the universe of facilities to be surveyed for 2011:

- Facilities that held a Title V permit in 2011;
- Any facility with emissions greater than 5 TPY for VOCs or 25 TPY for NO_x in 2008, 2009 or 2010, as previously reported to the DAQ inventory program; and
- Any facility that may be a significant source of emissions but for which DAQ does not have previous inventory data, or otherwise of particular interest.

Based on these criteria, 72 facilities statewide reported air emissions data for 2011. Since only New Castle and Sussex Counties have been designated within a marginal non-attainment area for the 2008 8-hour ozone standard, a total of 57 facilities will be presented in this report.

Emissions Summary

Table 2-1. 2011 Facility-Level Emissions for New Castle County

Facility Name	VOC		NO_x		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
A.I. DuPont Hospital	1	0.01	6	0.10	1	0.02
Air Liquide - Delaware City	< 1	< 0.01	0	0	< 1	< 0.01
Amtrak Maintenance Facility	2	< 0.01	4	0	3	0
Ashland Research Center (Hercules)	1	< 0.01	2	0.01	4	0.02
Astrazeneca Pharmaceuticals	1	< 0.01	7	0.04	7	0.02
BASF (Ciba Specialty Chemicals)	24	0.07	11	0.03	24	0.06
Calpine – Christiana (Conectiv)	< 1	< 0.01	1	0.42	< 1	0.01
Calpine - Delaware City (Conectiv)	< 1	< 0.01	< 1	0.06	< 1	< 0.01
Calpine - Edge Moor (Conectiv)	25	0.21	346	1.74	110	0.43
Calpine - Hay Road (Conectiv)	33	0.12	602	2.19	167	0.61
Calpine - West Substation (Conectiv)	< 1	< 0.01	< 1	0.20	< 1	0.01
Christiana Hospital	1	< 0.01	14	0.13	11	0.05
Clean Earth of New Castle	3	0.03	20	0.14	4	0.03
Croda (Uniqema)	4	0.01	24	0.09	26	0.08
Dassault Falcon Jet	14	0.03	1	< 0.01	1	< 0.01
Delaware City Refinery (Premcor)	303	1.22	1,072	4.51	617	2.14
Delaware City Terminal (Premcor)	18	0.05	< 1	< 0.01	< 1	< 0.01
Del. Correctional Center - Smyrna	< 1	< 0.01	5	0.01	7	0.02
Diamond Materials	3	0.03	4	0.05	13	0.13
DSWA Cherry Island Landfill	24	0.07	1	0.02	3	0.05
DuPont - Chestnut Run	3	0.02	48	0.15	5	0.01
DuPont - Edge Moor	99	0.29	27	0.08	2,051	5.97
DuPont - Red Lion	2	0.01	23	0.10	4	0.02
DuPont Building - Wilmington	< 1	< 0.01	6	0.06	5	0.03
DuPont Experimental Station	8	0.05	180	0.76	17	0.09
DuPont Stine-Haskell Lab	3	0.02	9	0.13	10	0.05
E-A-R Specialty Composites	2	0.01	< 1	< 0.01	< 1	< 0.01
Evraz Claymont Steel	69	0.20	166	0.49	346	1.03
Fisker (General Motors)	1	< 0.01	11	0.03	8	0.02
FMC	3	0.01	31	0.08	26	0.06
Formosa Plastics	59	0.16	32	0.10	22	0.05
FP International	2	0.01	1	< 0.01	1	< 0.01
Johnson Controls Battery	< 1	< 0.01	3	< 0.01	2	< 0.01
Kuehne Chemical	< 1	< 0.01	2	< 0.01	1	< 0.01
MacDermid	1	< 0.01	< 1	< 0.01	< 1	< 0.01
Magellan Terminals	39	0.10	2	< 0.01	1	< 0.01
Micropore	3	0.01	0	0	0	0
Printpack	44	0.13	3	0.01	3	0.01
Rohm & Haas Electronic Materials	7	0.03	4	0.02	5	0.02
Sunoco	46	0.10	54	0.14	111	0.10
University of Delaware - Newark	4	< 0.01	20	0.03	26	0.06
Veterans Administration Hospital	< 1	< 0.01	4	0.06	3	0.02
Wilmington WWTP	1	< 0.01	4	0.01	4	0.01
New Castle County Total	**836**	**3.02**	**2,750**	**12.02**	**3,649**	**12.32**

Table 2-2. 2011 Facility-Level Emissions for Sussex County

Facility Name	VOC		NO_x		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
Allenharim (Allen Family Foods)	< 1	0	2	0	2	0
Amick Farms (Allen's Milling)	< 1	< 0.01	4	0.05	3	0.02
DSWA Southern Landfill	11	0.03	40	0.13	233	0.61
Invista	7	0.02	2	0.09	10	0.06
Justin Tanks	6	0.02	0	0	0	0
Mountaire Farms - Millsboro	1	< 0.01	4	0.02	9	0.02
Mountaire Farms - Selbyville	< 1	< 0.01	17	0.05	2	0.01
Multi-Tech	8	0.04	0	0	0	0
NRG Indian River Power Plant	17	0.09	2,352	11.68	171	0.84
OSG Ship Management (Maritrans)	764	4.73	0	0	0	0
Perdue Farms - Bridgeville	< 1	< 0.01	5	0.02	4	0.01
Perdue Farms - Georgetown	< 1	< 0.01	8	0.02	5	0.01
Perdue Farms Agrirecycle	< 1	< 0.01	16	0.03	< 1	< 0.01
Pinnacle Foods	1	< 0.01	5	0.02	3	0.02
Sussex County Total	**815**	**4.94**	**2,456**	**12.10**	**442**	**1.60**

SECTION 3

STATIONARY NON-POINT SOURCES

Stationary non-point sources represent a large and diverse set of individual emission source categories. A non-point source category is either represented by small facilities too numerous to individually inventory, such as commercial cooking at restaurants and fuel combustion at a variety of small businesses, or is a common activity, such as residential open burning. Emissions from the non-point source categories were estimated at the county level.

Source Categories

There are a number of non-point source categories which contribute emissions of ozone precursors. These categories can be grouped into several category types. These include:

- **Solvent Use** – Many products used by homeowners and businesses contain VOC solvents to achieve the intended purpose of the product. Paints, cleaners, pesticides, personal care products, and inks are a few examples of products that contain VOC solvents.

- **Gasoline Usage** – The distribution and use of gasoline in vehicles and other gasoline-powered engines result in emissions of VOCs whenever the volatile gasoline vapors are allowed to escape.

- **Fuel Combustion** – The combustion of fuels in industrial, commercial, institutional, and residential furnaces, engines, boilers, wood stoves, and fireplaces create emissions of VOCs, NO_x and CO.

- **Open Burning** – Open burning creates emissions of VOCs, NO_x and CO. Open burning categories include trash burning, prescribed burning, burning of land clearing debris, wildfires, and house and vehicle fires.

Individual facilities are typically grouped with other like sources into a source category. Source categories are grouped in such a way that emissions are estimated collectively using one methodology. For the 2011 inventory, the distinction between point and non-point was defined by an annual emission threshold based on recent point source data (see Section 2 for point source criteria). Table 3-1 lists the source categories for which VOCs, NO_x and CO for New Castle and Sussex Counties were estimated.

Emission Estimation Methodologies and Activity Data

The 2008 Delaware Periodic Emission Inventory served as the starting point for non-point source category selection and methodology development. New methods were applied to some existing source categories, and emission factors were updated where available. New methods and emission factors came primarily from current *Emission Inventory Improvement Program, Volume III* documents and documented projects performed by the California Air Resource Board (CARB). Other sources of information included the *Compilation of Air Pollutant Emission Factors, Volume I*

(AP-42), the *Factor Information Retrieval System* (FIRE), and several projects performed by the Mid-Atlantic Regional Air Management Association (MARAMA), the Eastern Regional Technical Advisory Committee (ERTAC) and EPA.

Table 3-1. Non-point Source Categories Inventoried

VOC Emissions Only	Emissions of VOC, NO_x, and CO
Agricultural Pesticides	Agricultural Burning
AIM Coatings	Commercial Cooking
Asphalt Paving	Commercial Fuel Combustion
Autobody Refinishing	Industrial Fuel Combustion
Commercial & Consumer Products	Land Clearing Debris Burning
Degreasing	Prescribed Burning
Dry Cleaning	Residential Fuel Combustion
Gasoline (Petroleum) Marketing	Residential Open Burning
Graphic Arts	Residential Wood Combustion
Industrial Adhesives	Structure Fires
Industrial Surface Coatings	Vehicle Fires
Traffic Markings	Wildfires

Emissions from most non-point source categories were estimated by multiplying an indicator of collective activity by a corresponding emission factor. An indicator is any parameter associated with the activity level of a source, such as production, employment, fuel usage, or population that can be correlated with the emissions from that source. The corresponding emission factors are per unit of production, per employee, per unit of commodity consumed, or per capita, respectively. The basic equation that was applied to emission development for most non-point source categories is as follows:

$$Emissions\ (E) = Activity\ Data\ (Q) \times Emission\ Factor\ (EF)$$

If a source category had a regulatory control placed on it at the Federal or State level, the equation expands to the following:

$$E = Q \times EF \times [1 - (CE)(RE)(RP)]$$

where: CE = control efficiency
RE = rule effectiveness
RP = rule penetration

The control efficiency (CE) represents the typical emissions reduction achieved as compared to the otherwise uncontrolled emissions. A control may be a piece of equipment, such as a condenser used to recover vaporized solvent, or it may be an operational control, such as the use of only low VOC content paints.

Rule effectiveness (RE) reflects the ability of the regulatory program to achieve all emissions reductions that could have been achieved by full compliance with the applicable regulations at all sources at all times. If a rule is not being followed by all of the regulated community, then emissions will be higher than would otherwise be if there was 100% compliance. As an example, while the burning of trash is illegal under any circumstances in Delaware, the practice of burning household trash in backyard burn barrels still takes place in many rural areas of the State.

Rule penetration (RP) represents the percent of sources within a source category that are subject to the rule that requires control. As an example, gas stations that dispense more than 10,000 gallons of gasoline in a month are required by Delaware regulations to place vapor recovery systems on their gas pumps. Those dispensing less than 10,000 gallons are not required to install controls. Therefore, RP is less than 100%. In the case of the burning of trash or leaves, no person or business is exempt, and thus RP is 100%.

The mass balance approach was used for several source categories as an alternative to the use of an emission factor. The mass balance approach is applicable to VOC source categories where all of the VOC content in the products used (i.e., paints and adhesives) evaporates and is emitted as a result of the normal use of the product. Raw material or product purchase records were used to quantify emissions. Emissions were equated to the VOC content of the material usage minus amounts leaving the site as or in waste.

A major portion of the work involved in creating the 2011 non-point source inventory was in collecting activity data for each source category. The activity data gathered was related to the type of emission factors available and, in many cases, obtained from local sources. Surveys, letters, e-mails, and phone calls to individual businesses to obtain representative data for a source category was a technique used for several source categories. The type of activity data and the data source for each category is provided in Table 3-2.

Point source backout was performed for the industrial and commercial fuel combustion categories and many of the solvent usage categories to avoid double counting of emissions between point and non-point sources. Point source fuel usage was backed out from fuel consumption data obtained from the U.S. Department of Energy's (DOE) Energy Information Administration (EIA). Point source employment was backed out from employment data obtained from the Delaware Department of Labor.

Non-reactive VOCs were excluded from emission estimates. Emission factors specified as non-methane organic carbon (NMOC) in *AP-42* were used when available. In some instances, the *AP-42* emission factor was in terms of total organic carbon (TOC) and the percentage of the methane component was indicated in a footnote. In these cases, the emission factor was reduced by the percentage of methane to remove the non-reactive methane component in the emission total. For example, for evaporative emissions from crude oil, the methane component was 15 percent. The emission factor was reduced by 15 percent to remove methane from the calculation.

Source activity may fluctuate significantly on a seasonal basis. As an example, residential wood combustion is primarily performed outside the summer season. Paint usage, on the other hand, is used more often in the warmer months of the year. Because non-point source emissions are generally a direct function of source activity, seasonal changes in activity levels were examined

closely. Emissions were calculated on an annual basis. Summer season weekday (SSWD) daily emissions were developed through the use of a temporal allocation factor (TAF) applied to the annual emissions. Monthly and weekly profiles were used to develop the TAF. The monthly profile for each source category was developed through the use of monthly activity data, when available, or through EPA guidance (*Procedures, Volume I* and EIIP documents.) Most weekly profiles were developed through EPA guidance which defines activity taking place five, six, or seven days per week. Through EPA guidance, all TAFs include the work week. A few TAFs were developed based on the exact dates of episodic activity, such as firefighting training burns and wildfires.

Table 3-2. Summary of 2011 Non-point Source Activity Data

Source Category	Activity Data	Source of Activity Data
Agricultural Burning	Acreage and vegetation type	DAQ Area Source Compliance Program
Agricultural Pesticides	Planted crop acreage	Delaware Department of Agriculture
AIM Coatings	Solvents in U.S. paint shipments; U.S. Population	U.S. Census Bureau
Asphalt Paving	Cutback and emulsified asphalt usage	Delaware Department of Transportation
Autobody Refinishing	Employment data	Delaware Department of Labor
Commercial & Consumer Products	Population	Delaware Population Consortium
Commercial Cooking	Population	Delaware Population Consortium
Commercial Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Degreasing	Employment data	Delaware Department of Labor
Dry Cleaning	Facility-level solvent usage	DAQ Area Source Compliance Program
Gasoline (Petroleum) Marketing	Gasoline fuel sales; VMT through use of MOVES (Stage 2); employment data (comm. PFCs)	FHWA Motor Fuel Tax Administration; DelDOT (VMT); Delaware Department of Labor (employment data)
Graphic Arts	Employment data	Delaware Department of Labor
Industrial Adhesives	Population	Delaware Population Consortium
Industrial Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Industrial Surface Coatings	Employment data	Delaware Department of Labor
Land Clearing Debris Burning	Acreage disturbed during road, commercial, and residential construction	DAQ data calculated for the construction dust categories
Prescribed Burning	Acreage and vegetation type	DAQ Area Source Compliance Program
Residential Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Residential Open Burning	Rural households	U.S. Census Bureau
Residential Wood Combustion	Occupied households	Delaware Population Consortium
Structure Fires	Number of structures fires	Delaware Fire Marshal and DAQ Area Source Compliance Program
Traffic Markings	U.S. paint shipments; U.S. and State public road miles	U.S. Census Bureau; FHWA highway statistics publication
Vehicle Fires	Number of vehicle fires	Delaware Fire Marshal
Wildfires	Acreage and vegetation type	Delaware Division of Forestry

Emissions Summary

Tables 3-3 and 3-4 provide county summaries of the 2011 annual (tons per year, TPY) and SSWD (tons per day, TPD) emissions for each non-point source category for New Castle County and Sussex County, respectively. The totals may not match the sum of the individual values due to independent rounding.

Table 3-3. Summary of 2011 Non-point Emissions for New Castle County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	114	0.36	---	---	---	---
AIM Coatings	602	2.26	---	---	---	---
Asphalt Paving	< 1	< 0.01	---	---	---	---
Auto Refinishing	260	1.00	---	---	---	---
Commercial & Consumer Products	1,245	3.53	---	---	---	---
Dry Cleaning	< 1	< 0.01	---	---	---	---
Graphic Arts	57	0.21	---	---	---	---
Industrial Adhesives & Sealants	127	0.39	---	---	---	---
Industrial Surface Coating	91	0.35	---	---	---	---
Solvent Cleaning	191	0.68	---	---	---	---
Traffic Markings	6	0.06	---	---	---	---
Solvent Use Total	**2,692**	**8.85**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	119	0.41	---	---	---	---
Refueling and PFC Filling (Stage 2)	102	0.33	---	---	---	---
Underground Tank Breathing	81	0.24	---	---	---	---
Tank Trucks in Transit	7	0.02	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	23	0.07	---	---	---	---
Marinas	18	0.06	---	---	---	---
Portable Fuel Containers	241	0.83	---	---	---	---
CMV Loading and Transport	121	0.33	---	---	---	---
Gasoline Marketing Total	**712**	**2.29**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	18	0.03	332	0.60	270	0.50
Industrial	21	0.06	384	1.20	317	0.99
Residential Fossil Fuel	278	0.02	525	0.30	215	0.13
Residential Wood	633	0.07	60	0.01	3572	0.43
Fuel Combustion Total	**699**	**0.19**	**1,302**	**2.11**	**4,374**	**2.05**
OPEN BURNING						
Agricultural Burning	0	0	0	0	0	0
Residential Open Burning	1	< 0.01	< 1	< 0.01	11	0.01
Land Clearing Debris Burning	0	0	0	0	0	0
Prescribed Burning	15	0	7	0	325	0
Structure Fires	3	0.01	< 1	< 0.01	14	0.03
Vehicle Fires	1	< 0.01	< 1	< 0.01	4	0.01
Wildfires	0	0	0	0	0	0
Open Burning Total	**20**	**0.01**	**8**	**< 0.01**	**353**	**0.05**
MISCELLANEOUS SOURCES						
Commercial Cooking	20	0.05	---	---	52	0.14
NON-POINT SECTOR TOTAL	**4,882**	**11.39**	**1,324**	**2.11**	**3,425**	**2.24**

Table 3-4. Summary of 2011 Non-point Emissions for Sussex County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
SOLVENT USE						
Agricultural Pesticides	471	1.40	---	---	---	---
AIM Coatings	222	0.83	---	---	---	---
Asphalt Paving	1	0.01	---	---	---	---
Auto Refinishing	44	0.17	---	---	---	---
Commercial & Consumer Products	459	1.30	---	---	---	---
Dry Cleaning	1	< 0.01	---	---	---	---
Graphic Arts	14	0.05	---	---	---	---
Industrial Adhesives & Sealants	40	0.12	---	---	---	---
Industrial Surface Coating	45	0.17	---	---	---	---
Solvent Cleaning	85	0.32	---	---	---	---
Traffic Markings	6	0.06	---	---	---	---
Solvent Use Total	**1,388**	**4.45**	---	---	---	---
GASOLINE MARKETING						
Retail Gasoline Stations						
Tank Truck Unloading (Stage 1)	73	0.25	---	---	---	---
Refueling and PFC Filling (Stage 2)	70	0.23	---	---	---	---
Underground Tank Breathing	47	0.14	---	---	---	---
Tank Trucks in Transit	4	0.01	---	---	---	---
Other Gasoline Marketing Activities						
Aircraft Refueling	9	0.03	---	---	---	---
Marinas	53	0.17	---	---	---	---
Portable Fuel Containers	93	0.32	---	---	---	---
CMV Loading and Transport	66	0.18	---	---	---	---
Gasoline Marketing Total	**415**	**1.34**	---	---	---	---
FUEL COMBUSTION						
Commercial/Institutional	3	< 0.01	67	0.10	445	0.07
Industrial	10	0.03	180	0.57	149	0.47
Residential Fossil Fuel	8	0.01	191	0.17	95	0.09
Residential Wood	318	0.06	27	< 0.01	1755	0.31
Fuel Combustion Total	**338**	**0.10**	**466**	**0.84**	**2,043**	**0.94**
OPEN BURNING						
Agricultural Burning	4	0	2	0	64	0
Residential Open Burning	6	0.01	3	< 0.01	50	0.05
Land Clearing Debris Burning	5	0.01	2	0.01	75	0.21
Prescribed Burning	4	0	2	0	94	0
Structure Fires	3	< 0.01	< 1	< 0.01	15	0.02
Vehicle Fires	< 1	< 0.01	< 1	< 0.01	1	< 0.01
Wildfires	5	0.04	2	0.02	102	0.77
Open Burning Total	**28**	**0.06**	**11**	**0.03**	**401**	**1.06**
MISCELLANEOUS SOURCES						
Commercial Cooking	7	0.01	---	---	19	0.05
NON-POINT SECTOR TOTAL	**2,177**	**5.95**	**478**	**0.86**	**2,463**	**2.05**

SECTION 4

NON-ROAD MOBILE SOURCES

Non-road mobile sources represent a large and diverse set of off-road vehicles and non-stationary equipment. Emission estimates of VOCs, NO_x and CO for this source sector account for exhaust emissions from engine fuel combustion.

Non-road vehicles and equipment are grouped into four source category types for the purpose of developing emission estimates. These include:

- **Aircraft** – Commercial, military, and private aircraft are considered under this source category.

- **Locomotives** – Commercial line haul and yard locomotives are considered under this source category.

- **Commercial Marine Vessels (CMVs)** – Various types of vessels that navigate the Delaware Bay and River and the Chesapeake and Delaware Canal are included under this source category. Recreational boats are included in the next category.

- **Other Off-road Vehicles and Equipment** – All other off-road emission sources are accounted for through the use of EPA's NONROAD model. The NONROAD model compiles off-road equipment pertinent to Delaware into the following subcategories:

    - Recreational (land-based);
    - Construction;
    - Industrial;
    - Lawn and Garden;
    - Agricultural;
    - Commercial;
    - Logging;
    - Airport Ground Support;
    - Recreational Marine; and
    - Railway Maintenance.

Individual equipment SCCs covered in the NONROAD model are further broken down by the fuel type, including 2-stroke gasoline, 4-stroke gasoline, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG).

Emission Estimation Methodologies

The 2008 Delaware Periodic Emission Inventory served as the starting point for non-road source category selection and methodology development. No new sources were added to Delaware's off-road mobile source inventory. However, a new version of the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS) were used for 2011.

Similar to the estimation of stationary non-point emissions, off-road equipment emissions were estimated by multiplying an indicator of collective activity within the inventory area for a source category by a corresponding emission factor. The indicators of activity for off-road sources include landing and take-offs (LTOs), vessel port-of-calls, time-in-mode (TIMs, which are pertinent to aircraft and CMVs), gross ton miles (locomotives), equipment populations and economic activity (both pertinent to NONROAD equipment) that can be correlated with the emissions from that source. The corresponding emission factors are amount of pollutant (either grams or pounds) per unit of fuel used (locomotives and military/commercial aircraft), per LTO (air taxi and general aviation) or per unit of power output in brake horsepower or kilowatt-hours (NONROAD equipment and CMVs, respectively).

A major portion of the work involved in creating the 2011 non-road source inventory was in collecting activity data for each source category. The activity data gathered was related to the type of emission factors available and, in many cases, obtained from local sources. More information about gathering activity data for each source category is presented below.

There are no point source data that must be backed out of the non-road mobile source sector. Even though larger airports may report as a point source, their reported point source emissions do not include ground support equipment or aircraft engine emissions. Also, aircraft emissions are estimated only for LTOs that take place at a Delaware airport. Emissions from aircraft that transit Delaware airspace are not included in Delaware's inventory.

Emissions Summary

Tables 4-1 and 4-2 provide county summaries of the 2011 annual (tons per year, TPY) and SSWD (tons per day, TPD) emissions for aircraft, locomotives, commercial marine vessels, and all equipment emissions estimated using EPA's NONROAD model. The non-road sector is a significant contributor to ozone precursors in Delaware.

Table 4-1. Summary of 2011 Non-road Emissions for New Castle County

	VOC		NO_X		CO	
Source Categories	**TPY**	**TPD**	**TPY**	**TPD**	**TPY**	**TPD**
NONROAD Model Equipment	1,888	6.76	1,760	6.23	19,849	76.90
Aircraft	31	0.09	56	0.13	630	1.86
Locomotives	19	0.05	233	0.64	48	0.13
Commercial Marine Vessels	51	0.14	1,528	4.19	161	0.44
NEW CASTLE COUNTY TOTAL	**1,989**	**7.04**	**3,577**	**11.19**	**20,688**	**79.33**

Table 4-2. Summary of 2011 Non-road Emissions for Sussex County

Source Categories	VOC		NO_X		CO	
	TPY	TPD	TPY	TPD	TPY	TPD
NONROAD Model Equipment	2,507	8.34	1,738	6.34	16,531	59.38
Aircraft	8	0.02	1	< 0.01	259	0.78
Locomotives	2	< 0.01	21	0.06	5	0.01
Commercial Marine Vessels	41	0.11	1,285	3.62	122	0.33
SUSSEX COUNTY TOTAL	**2,558**	**8.47**	**3,045**	**10.02**	**16,917**	**60.50**

NONROAD Model Equipment

DAQ used NONROAD2008a to develop 2011 annual emission estimates for New Castle County and Sussex County. Most equipment covered by the NONROAD model is powered by diesel-fueled compression-ignition engines or gasoline-fueled spark-ignition engines. Engines fueled by compressed natural gas (CNG) and liquefied petroleum gas (LPG) engines are also included in the NONROAD model. Table 4-3 lists general SCCs addressed by the NONROAD model. Equipment categories are defined at the 7-digit SCC level (with recreational marine and railway maintenance being exceptions) and specific equipment are defined at the 10-digit SCC level.

To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. Geographic allocation factors (GAFs) are used to distribute national equipment populations to states/counties. These factors are based on surrogate indicators of equipment populations. For example, harvested cropland is the surrogate indicator used in allocating agricultural equipment. A national average engine activity (i.e., load factor times annual hours of use) is used in NONROAD.

To improve the accuracy of the model runs, default inputs were replaced in the NONROAD model option files for select parameters. In the options packet, inputs that can be replaced include: Reid vapor pressure (RVP), temperature, oxygenated fuel weight percent, and fuel sulfur levels. Local activity data inputs, such as equipment populations or activity (e.g., hours of use or load factors), can also replace default values in the model.

NONROAD model option files were prepared to account for temperatures and fuel characteristics representative of each county for each of the four seasons (winter, spring, summer, and fall). Temperature and fuel input values for each three-month period (December-February, March-May, June-August, and September-November) were averaged to estimate seasonal values. Minimum, maximum, and average temperatures per month were obtained from the National Weather Service for the New Castle County Airport and the Georgetown Airport. Table 4-4 presents a summary of county temperature and gasoline fuel characteristics data used for each season. A sulfur content of 15 ppm for off-road diesel fuel was used for 2011 based on EPA requirements.

Table 4-3. SCCs Addressed by the NONROAD Model

Nonroad SCCs	SCC Descriptions	Nonroad SCCs	SCC Descriptions
2260xxxxxx	2-stroke gasoline engines	2268xxxxxx	CNG engines
2260001xxx	- recreational vehicles	2268002xxx	- construction equipment
2260002xxx	- construction equipment	2268003xxx	- industrial equipment
2260003xxx	- industrial equipment	2268005xxx	- agricultural equipment
2260004xxx	- lawn & garden equipment	2268006xxx	- light commercial equipment
2260005xxx	- agricultural equipment	226801xxxx	- oil field equipment
2260006xxx	- light commercial equipment	2270xxxxxx	Diesel engines
2260007xxx	- logging equipment	2270001xxx	- recreational vehicles
2265xxxxxx	4-stroke gasoline engines	2270002xxx	- construction equipment
2265001xxx	- recreational vehicles	2270003xxx	- industrial equipment
2265002xxx	- construction equipment	2270004xxx	- lawn & garden equipment
2265003xxx	- industrial equipment	2270005xxx	- farm equipment
2265004xxx	- lawn & garden equipment	2270006xxx	- light commercial equipment
2265005xxx	- agricultural equipment	2270007xxx	- logging equipment
2265006xxx	- light commercial equipment	2270008xxx	- airport service equipment
2265007xxx	- logging equipment	2270009xxx	- underground mining equipment
2265008xxx	- airport service equipment	227001xxxx	- oil field equipment
226501xxxx	- oil field equipment	2282xxxxxx	Recreational marine equipment
2267xxxxxx	LPG engines	2285xxx015	Railway maintenance equipment
2267001xxx	- recreational vehicles		
2267002xxx	- construction equipment		
2267003xxx	- industrial equipment		
2267004xxx	- lawn & garden equipment		
2267005xxx	- agricultural equipment		
2267006xxx	- light commercial equipment		
2267008xxx	- airport service equipment		

Table 4-4. NONROAD Model Temperature and Fuel Characteristic Input Values by Season for 2011

County	Season	Oxygen Weight %	RVP psi	Gasoline Sulfur ppm	Daily Average Temperature, °F		
					Minimum	Maximum	Average
New Castle	Summer	3.6	6.9	43.6	67	86	77
New Castle	Autumn	3.67	9.105	46.55	50	67	58
New Castle	Winter	3.79	11.31	49.5	28	43	36
New Castle	Spring	3.67	9.105	46.55	46	64	55
Sussex	Summer	3.58	7	49.1	67	87	76
Sussex	Autumn	3.715	9.155	43.35	52	70	61
Sussex	Winter	3.85	11.31	37.6	30	48	39
Sussex	Spring	3.715	9.155	43.35	47	65	56

DAQ researched the availability of state and county-specific data to improve upon the default equipment populations and GAFs incorporated in the model. DAQ replaced the default equipment population of recreational marine equipment with Delaware-specific data. DAQ used recreational boat registration data provided by the Delaware Division of Fish and Wildlife to estimate the total recreational marine equipment population in use within Delaware waters. DAQ determined this to be a preferable approach to the NONROAD default approach of a top-down allocation of the national equipment population. However, registration data were not used

to allocate recreational marine activity to the county level because residents may register their boats in one county, but use their boats in other parts of the State or neighboring counties.

DAQ updated GAFs for numerous equipment categories. Table 4-5 provides a list of GAFs and the associated equipment populations that use the GAFs that were updated with 2011 Delaware-specific data. For golf carts, DAQ replaced the GAFs based on the number of golf courses in each county with the county total square kilometers of golf courses in each county. DAQ believes that golf cart usage is more directly related to the size of each golf course than to the number of courses that exist in each county. If an equipment population is not identified in Table 4-5, then the model default GAFs were used in the 2011 runs.

Table 4-5. 2011 Delaware-specific Geographic Allocation Factors

Geographic Allocation Factor	Data Source	Equipment Population
Population	DE Population Consortium	
Aircraft NOx emissions	Delaware 2008 inventory	Airport ground support
Construction employment and building permits	U.S. Census Bureau	Construction
Harvested crop acres	DE Department of Agriculture	Agricultural
Forest harvest permit acres	DE Department of Agriculture	Logging
Area of golf courses	Delaware State Golf Association	Golf carts
Wholesale businesses	DE Department of Labor	Commercial
Single and duplex housing	U.S. Census Bureau	Residential lawn & garden
Landscaping businesses	DE Department of Labor	Commercial lawn & garden
Manufacturing employees	DE Department of Labor	Industrial
Class I Rail gross ton miles	Class I Operators in Delaware	Rail maintenance
Rural land area	U.S. Census Bureau	Land-based recreational
Snowfall	Weather Warehouse website	Snow blowers and snowmobiles

Sample Calculations and Results

The standard NONROAD model emission equation is as follows:

$$I_{exh} = E_{exh} * A * L * P * N$$

where: I_{exh} = Exhaust emissions, (ton/year)
E_{exh} = Exhaust emission factor, (ton/hp-hr)
A = Equipment activity, (hours/year)
L = Load factor, (proportion of rated power used on average basis)
P = Average rated power for modeled engines, (hp)
N = Equipment population

Table 4-6. 2011 New Castle County Emissions for NONROAD Equipment

		Annual (TPY)			SSWD (TPD)		
Fuel Type	**Equipment Category**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Gasoline	All Equipment	1,726	348	18,311	6.18	1.23	70.94
Diesel	All Equipment	130	1,278	692	0.46	4.52	2.68
LPG	All Equipment	32	122	778	0.12	0.43	3.01
CNG	All Equipment	< 1	12	67	< 0.01	0.04	0.26
All Fuels	**Total**	**1,888**	**1,760**	**19,849**	**6.76**	**6.23**	**76.90**

Table 4-7. 2011 Sussex County Emissions for NONROAD Equipment

		Annual (TPY)			SSWD (TPD)		
Fuel Type	**Equipment Category**	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
Gasoline	All Equipment	2,368	463	15,151	7.87	1.69	54.42
Diesel	All Equipment	109	1,157	587	0.36	4.22	2.11
LPG	All Equipment	30	110	739	0.10	0.40	2.65
CNG	All Equipment	< 1	8	54	< 0.01	0.03	0.19
All Fuels	**Total**	**2,507**	**1,738**	**16,531**	**8.34**	**6.34**	**59.38**

Aircraft

The aircraft source category includes emissions from commercial, air taxi, general aviation, and military aircraft. These sub-categories are described as follows:

- Commercial aircraft are used for scheduled service transporting passengers, freight, or both;
- Air taxis are used for scheduled service carrying passengers and/or freight, but are smaller aircraft that operate on a more limited basis than the commercial carriers;
- General aviation includes other non-military aircraft used for recreational flying, business, personal transportation, and various other activities; and
- Military aircraft are used by the U.S. military in a wide range of missions.

Airport-specific emissions for all aircraft sub-categories were allocated to the county in which each airport is located. Where there are multiple airports in a given county, the emissions were summed to provide a county-level emissions estimate. Aircraft emissions are reported under the following SCCs:

Table 4-8. SCCs for Aircraft

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2275001000	Mobile Sources	Aircraft	Military Aircraft	Total
2275020000	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
2275050000	Mobile Sources	Aircraft	General Aviation	Total
2275060000	Mobile Sources	Aircraft	Air Taxi	Total

DAQ estimated annual aircraft emissions using a combination of airport-specific activity data and Federal Aviation Administration (FAA)/EPA emission factors. Estimating aircraft emissions focuses on the "mixing zone," which has a height (mixing height) equal to the thickness of the inversion layer. Air emissions within this zone are trapped by the inversion layer and ultimately affect ground-level pollutant concentrations. When aircraft are above the mixing zone, emissions tend to disperse and have no ground-level effects. The aircraft operations within the mixing zone are defined by the landing and take-off (LTO) cycle. Each LTO cycle consists of five specific operating modes:

- Approach – aircraft operates in this mode when it approaches the airport on its descent from the mixing height to when it lands on the runway.
- Taxi/idle-in – aircraft operates in this mode when it taxis from the runway to the gate and turns its engines off.
- Taxi/idle-out – this period occurs from engine start-up to take-off as the aircraft taxis from the gate back out to the runway.
- Take-off – this mode is characterized primarily by full-throttle operation that typically lasts until the aircraft reaches between 500 and 1000 feet above ground, which is when engine power is reduced.
- Climb-out – this mode begins right after the take-off mode and lasts until the aircraft passes out of the mixing height.

The operation time in each of these modes is dependent on the aircraft category, local meteorological conditions, and operational considerations at a given airport. The time-in-mode (TIM) for the take-off operating mode is the least variable.

The following are the general steps to be used to estimate aircraft emissions:

- Determine the mixing height to be used to define the LTO cycle;
- Define the fleet make-up for each airport;
- Determine airport activity in terms of the number of LTOs by aircraft/engine type;
- Select emission factors for each engine model associated with the aircraft fleet;
- Estimate the TIM for the aircraft fleet at each airport;
- Calculate emissions based on aircraft LTOs, emission factors for each aircraft engine model, and estimated aircraft TIM; and
- Aggregate the emissions across aircraft.

LTO data were obtained from all airports in New Castle County and Sussex County. Data on specific aircraft and engine types were obtained only from the New Castle County airport. Table 4-9 provides the LTO data by the four aircraft types for airports in New Castle County and Sussex County.

Table 4-9. 2011 LTO Data for New Castle and Sussex Counties

Airport	County	Category	LTOs
New Castle County	New Castle	Military	6,180
New Castle County	New Castle	Commercial	39
New Castle County	New Castle	Air Taxi	3,463
New Castle County	New Castle	General Aviation	47,305
Summit	New Castle	General Aviation	42,200
Sussex County	Sussex	General Aviation	34,000
Laurel	Sussex	General Aviation	9,100

DAQ used these airport-specific LTO data to estimate commercial and military aircraft emissions using FAA's Emissions and Dispersion Modeling System (EDMS), Version 5.1.4.1. The model requires detailed inputs on aircraft operation by aircraft and engine type. DAQ matched the aircraft LTO data to the existing aircraft/engine types in EDMS, and used the default EDMS TIM data. A mixing height of 2,300 feet was used for both airports in New Castle County based on an isopleth chart of annual average morning mixing heights for the continental U.S. as provided in EPA's *Procedures* Manual. The Delaware Army National Guard (DE ARNG) and the Delaware Air National Guard (DE ANG) operate units at the New Castle County Airport and contribute to the military LTOs at that airport.

EDMS generates emissions for VOCs, NO_x and CO in tons per year. The model also generates emissions for ground support equipment (GSE). However, DAQ used the GSE estimates generated from the NONROAD model, so these were subtracted from the EDMS results. EPA fleet average emission factors were applied to the LTO data to estimate annual general aviation and air taxi emissions.

Sample Calculations and Results

Commercial and Military Aircraft

The equation below is the calculation of taxi and queue mode time that is an airport-specific input in EDMS.

$$\textit{Taxi and Queue Mode Time} = (\textit{Airport Average Taxi-In Time} + \textit{Airport Average Taxi-Out Time}) - \textit{EDMS Aircraft-Specific Landing Roll Time}$$

The following is the equation used in EDMS to calculate annual emissions by aircraft type for one LTO cycle:

$$E_{ij} = \Sigma\,[(TIM_{jk}) * (FF_{jk}/1000) * (EI_{ijk}) * (NE_j)]$$

where:

E_{ij} = Total emission of pollutant *i*, in pounds, produced by aircraft type *j* for one LTO cycle.
TIM_{jk} = Time in mode for mode *k*, in minutes, for aircraft type *j*
FF_{jk} = Fuel flow for mode *k*, in pounds per minute, for each engine used on the aircraft type *j*
EI_{ijk} = Emission index for pollutant *i*, in pounds of pollutant per one thousand pounds of fuel, in mode *k* for aircraft type *j*
NE_j = Number of engines used on aircraft type *j*

Finally, annual emissions per airport are calculated with the following equation:

$$\textit{Annual Emissions for Airport A (tons/yr)} = \Sigma\,[(E_{ij} * LTO_j)]/2000\ \textit{lbs/ton}$$

where:

$E_{i,j}$ = annual emissions in pounds of pollutant *i*, produced by aircraft type *j* per LTO cycle.
$LTOs_j$ = annual number of LTOs for aircraft type j

Air Taxi and General Aviation Aircraft

The following equation is the estimate of air taxi and general aviation aircraft emissions using LTO data and fleet average emission factors.

$$E_i = LTOs \times EF_i \times {}^{1}\!/_{2000}$$

where:

E_i = annual emissions in tons of pollutant *i*
LTOs = annual number of LTOs
EF_i = default aviation fleet mix emission factor in pounds of pollutant for pollutant *i*

Table 4-10. 2011 Annual Emissions by County for Aircraft

SCC	Aircraft Category	County	Annual (TPY)			SSWD (TPD)		
			VOC	NO_X	CO	VOC	NO_X	CO
2275001000	Military	New Castle	12	52	44	0.03	0.12	0.10
2275020000	Commercial	New Castle	< 1	< 1	< 1	< 0.01	< 0.01	< 0.01
2275050000	General Aviation	New Castle	17	3	538	0.05	0.01	1.62
2275060000	Air Taxi	New Castle	2	< 1	49	0.01	< 0.01	0.14
22750xxxxx	**Total: Aircraft**	**New Castle**	**31**	**56**	**630**	**0.09**	**0.13**	**1.86**
2275050000	General Aviation	Sussex	8	1	259	0.02	< 0.01	0.78

Locomotives

Railroad locomotives are a combustion source of emissions with most significant emissions occurring where there is a concentration of railroad activity (such as a large switch yard). The primary fuel consumed by railroad locomotives is distillate oil (diesel fuel). Locomotives can perform two different types of operations: line haul and yard (or switch). Line haul locomotives generally travel between distant locations, such as from one city to another. Yard locomotives are primarily responsible for moving railcars within a particular railway yard. Locomotive emissions are reported under the SCCs provided in Table 4-11.

For line haul locomotives, DAQ calculated Class I operation emissions separately from Class II/III operations. Line haul locomotive emissions for passenger trains and commuter lines were estimated to be zero since rail service in Delaware (Amtrak and SEPTA) is electric powered. Fuel consumption was used to estimate locomotive engine emissions. Fuel consumption rates are usually known only for the entire interstate operating region, therefore, it is necessary to allocate the total amount of fuel consumed "system-wide" to Delaware and its counties.

Table 4-11. SCCs for Locomotives

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2285002006	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations
2285002007	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class II/Class III Operations
2285002010	Mobile Sources	Railroad Equipment	Diesel	Yard Locomotives

Line Haul Locomotives – Class I Operations

CSX Transportation operates Class I locomotives within New Castle County, while Norfolk Southern operates throughout the State of Delaware. DAQ contacted these companies to obtain estimates of fuel consumption or data to calculate fuel consumption (e.g., gross ton-miles (GTM) and gallons of fuel consumed per GTM).

Norfolk Southern provided GTM data at the state level. To obtain emissions at the county level, DAQ used the same county allocations as was used in the 2008 inventory. Norfolk Southern provided a fuel consumption index (GTM/fuel consumed) for the system that includes operations in Delaware. CSX provided GTM and fuel consumption data for New Castle County, the only county in which CSX operates in Delaware.

Line Haul Locomotives – Class II/III Operations

The Maryland & Delaware Railroad operates in New Castle County and Sussex County. The Delaware Coast Line Railroad operates only in Sussex County. Both companies provided 2011 statewide fuel consumption data. For the Maryland & Delaware Railroad, track miles within each county were used to allocate statewide fuel consumption to each county.

The system-wide fuel consumption indices, county-specific GTM, and calculated county-level fuel consumption for both Class I and Class II/III line-haul operations are provided in Table 4-12.

Table 4-12. 2011 Locomotive Fuel Consumption Data by County for Class I Line Haul Operations

Railroad Company	Class	County	Gross Ton Miles (GMT)	System-wide GTM/Gallon Diesel	Fuel Consumed, gallons/year
Norfolk Southern	I	New Castle	216,496,634	1,083.52	199,808
Norfolk Southern	I	Sussex	126,647,379	1,083.52	116,885
CSX Transportation	I	New Castle	688,000,000	903.75	761,275
Maryland & Delaware	II/III	New Castle	----	----	2,380
Maryland & Delaware	II/III	Sussex	----	----	3,331
Delaware Coast Line	II/III	Sussex	----	----	9,000

Yard Locomotives

Table 4-13 provides a summary of switchyard operations and fuel consumption by rail company and county. CSX and Maryland & Delaware provided Delaware-specific fuel consumption for 2008, which was assumed to remain the same for 2011. An average switchyard engine fuel consumption estimate of 32,447 gallons per year was applied based on a recent regional study coordinated through the Eastern Regional Technical Advisory Committee.

Table 4-13. 2011 Switchyard Activity and Estimated Fuel Consumption

Class I Switchyard	County	No. of Yard Locomotives	Fuel Consumed, gallons/year
Norfolk Southern	New Castle	13	421,813
CSX Transportation	New Castle	3	180,000
Maryland & Delaware	New Castle	1	9,640
Maryland & Delaware	Sussex	2	19,281

Sample Calculations and Results

Line Haul Locomotive

To determine the amount of pollutant ***p*** at the county level:

$$E_{px} = FC \times EF_p \times 1/2000$$

where: E_p = amount of pollutant ***p*** emitted for the county in pounds
FC = fuel consumption for the county in gallons
EF_p = emission factor for pollutant ***p*** in pounds per gallon

Yard Locomotive

To determine the amount of pollutant ***p*** at the county-level:

$$E_p = Yd * FC_{Yd} * EF_p$$

where: E_p = amount of pollutant ***p*** emitted for the county in pounds
Yd = number of yard locomotives in the county
FC_{Yd} = fuel consumption per yard locomotive in gallons per year
EF_p = emission factor for pollutant ***p*** in pounds per gallon

Table 4-14. 2011 Locomotives Emissions by County

SCC	Category Description	County	Annual (TPY)			SSWD (TPD)		
			VOC	NO_X	CO	VOC	NO_X	CO
2285002006	Class I Line Haul	New Castle	9	109	30	0.02	0.30	0.08
2285002007	Class II/III Line Haul	New Castle	< 1	1	< 1	< 0.01	< 0.01	< 0.01
2285002010	Yard Locomotives	New Castle	10	123	19	0.03	0.34	0.05
22850020xx		**Total: New Castle**	**19**	**233**	**48**	**0.05**	**0.64**	**0.13**
2285002006	Class I Line Haul	Sussex	1	13	4	< 0.01	0.04	0.01
2285002007	Class II/III Line Haul	Sussex	< 1	4	< 1	< 0.01	0.01	< 0.01
2285002010	Yard Locomotives	Sussex	< 1	4	1	< 0.01	0.01	< 0.01
22850020xx		**Total: Sussex**	**2**	**21**	**5**	**< 0.01**	**0.06**	**0.01**

Commercial Marine Vessels

The CMV sector includes many types of vessels, such as large deep-draft vessels, barge towboats, harbor tugs, dredging vessels, ferries, excursion vessels, and commercial fishing vessels. In addition to the numerous vessel types, each vessel type engages in different activities such as hoteling, maneuvering within the port, and cruising.

In its 1999 final rule for commercial marine diesel engines, EPA defined three categories of marine diesel engines based on engine displacement, power and revolutions per minute (rpm). Table 4-15 presents the definitions for each category.

Table 4-15. U.S. EPA Marine Engine Category Definitions

Category	Displacement per cylinder	Power range (kW)	RPM range
1	disp. < 5 liters and power $\geq$ 37 kW	37 - 2,300	1,800 - 3,000
2	5 $\leq$ displacement < 30 liters	1,500 - 8,000	750 - 1,500
3	displacement $\geq$ 30 liters	2,500 - 80,000	60 - 900

The EPA classifies CMV emissions by fuel type (residual and diesel) and by mode of operation (port and underway). CMVs often burn multiple types of fuel and may burn different fuels for different operating modes or locations (i.e., near ports). DAQ used the port and underway SCCs to characterize the CMV emissions as listed in Table 4-16. The SCC classification is based on the most common type of fuel utilized by the vessel category. Ocean-going vessels (OGV) predominately burn intermediate fuel oil (IFO). DAQ placed emissions from OGVs burning IFO in the residual fuel SCC. This is consistent with how petroleum product sales data are reported by the Energy Information Administration and EPA's classification of fuels.

Table 4-16. SCCs for Commercial Marine Vessels

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2280002100	Mobile Sources	Marine Vessels, Commercial	Diesel	Port emissions
2280002200	Mobile Sources	Marine Vessels, Commercial	Diesel	Underway emissions
2280003100	Mobile Sources	Marine Vessels, Commercial	Residual	Port emissions
2280003200	Mobile Sources	Marine Vessels, Commercial	Residual	Underway emissions

There are four activity modes for CMV; cruise, reduced speed zone (RSZ), maneuver, and hotel. Underway emissions are estimated as the combined activity of cruise and RSZ modes. Port emissions are estimated as the combined activity of maneuvering and hoteling modes. Emissions from ferries and dredging are considered port emissions since these vessels operate primarily within the port area.

DAQ calculated emissions for ocean-going vessels, towboats, tug-assist vessels, ferries and vessels associated with dredging operations. CMV engine emissions are assumed to be a function of the following:

- Mode of operation,
- Vessel type (bulk carrier, tanker, towboat, etc.);
- Vessel dead weight tonnage (DWT);
- Type of engine (2-stroke, 4-stroke, or steam); and
- Length of waterway segment.

Therefore, DAQ accounted for these variations when estimating CMV activity. The four modes of operation that are performed by vessels are defined below:

Cruise - This mode is assumed to begin 25 miles out from the port breakwater until the vessel reaches the breakwater. The breakwater is located at the mouth of the Delaware Bay. Cruise mode is only applicable to Sussex County.

Reduced Speed Zone (RSZ) - This mode begins at the breakwater and continues until the vessel is one to two nautical miles from the berth or anchorage. The vessel is assumed to have a speed of twelve knots during this mode. This mode is also referred to as transit, and escort for towboats and tug-assist vessels.

Maneuvering - This mode is defined as the time the vessel slows to below four knots until the dock lines are secure. This mode is also referred to as assist mode for tug-assist vessels.

Hoteling - This mode is defined as the time the vessel is at dock. During this mode, the vessel operates auxiliary engines for electrical power.

The waterway segment distances used to estimate activity and to allocate the activity to each county were estimated from the Google Earth website in 2008 by tracing the shipping channel. Segment distances are shown in Table 4-17. The distance South is given to the breakwater at the mouth of the Delaware Bay. The distance north is given to the Delaware-Pennsylvania border. The distance for the C&D Canal East is given from the Delaware-Maryland border to the entrance of the Delaware River (Reedy Point).

The engine activity for each mode is calculated using the following equation:

$$Activity_{mode} = Power \times LoadFactor \times Time_{mode} \times Calls$$

where:

$Activity_{mode}$	=	activity by mode (kilowatt-hours)
Power	=	rated engine power by vessel and engine type (kilowatts)
Load Factor	=	load factor of the engine by vessel type and mode
Time	=	time in mode per call by vessel type (hours)
Calls	=	number of calls by vessel and engine type

Table 4-17. Waterway Segment Distances for the Delaware River Area

Waterway Segment	Distance (mi.)
Point	**South**
DE/PA Border	83.8
Oceanport	83.3
Port of Wilmington	76.1
Magellan Terminal	75.6
Delaware City Refinery	66.0
C&D Canal	62.6
Latitude 39°30'	57.7
New Castle Co/Kent Co	48.5
Kent Co/Sussex Co	15.9
Point	**North**
Port of Wilmington	7.7
C&D Canal	21.2
Point	**East**
C&D Canal	13.0

This calculation must be performed for both propulsion and auxiliary engines and for each mode. Both propulsion engines and auxiliary engines are operating during cruise, RSZ and maneuvering modes. Only auxiliary engines operate during hoteling. Once the activity is calculated, it is allocated to the county level using county allocation factors.

This approach to calculating activity of CMVs was used for all vessel types except vessels involved in dredging activity. For dredging, the activity data used for emissions calculations was the volume of material dredged. Details on the sources and development of activity data are provided in the following subsections.

Ocean-Going Vessels

DAQ obtained vessel call data for ocean-going vessels (OGVs) during calendar year 2011 from the Marine Exchange for the Delaware River and Bay. Data were obtained for vessels that called on ports in Delaware, New Jersey and Pennsylvania. The data for the entire port area is required since the majority of vessels pass through Delaware waters en route to other ports. The vessel call data included the vessel name, ship type, DWT, pier, and the date of the call. The ship types calling on the Delaware River Area ports in 2011 are shown in Table 4-18.

Vessels may shift between piers during the same call on the Delaware River area. DAQ adjusted the vessel call data to remove shifts between piers, where possible, to avoid double counting using a methodology recommended by the staff of the Marine Exchange. Data on the engine power and engine type (2-stroke, 4-stroke, and steam) used on OGVs were not available through the Marine Exchange. Therefore, DAQ assigned engine power and engine type based on average engine data obtained from other sources.

For propulsion engines, the average engine power and the engine type were obtained from the EPA report *Commercial Marine Activity for Deep Sea Ports in the United States* (*Deep Sea Ports*). This report presents data for vessels that called on the Delaware River area ports during calendar year 1996. Note that the Delaware River area includes ports in Delaware, New Jersey and Pennsylvania, which are located on the Delaware River. The number of calls by vessel and engine type is presented for specific DWT ranges. The average engine power is also given.

Table 4-18. Vessel Types Calling on Delaware River Area Ports in 2011

Codes	Main Vessel Type	Additional Vessel Types Included w/ Main Type
BU	Bulk	Bulk Cargo (BG), Chemical (CH), Bulk (HR)
CC	Container	Container/Bulk (CB), Part Container (PC)
GC	General Cargo	
MS	Miscellaneous	Livestock (LV), Tall Ship (TS)
PR	Passenger	
RF	Refrigerated Cargo (Reefer)	Container Reefer (CR)
RR	Roll on-Roll off (RORO)	RORO Container (RC)
TA	Tanker	Tanker (AS), Bulk Oil (BO), Chemical Oil Tanker (CO), Gas Carrier (PG and NG)
VE	Vehicle Carrier	

In order to calculate underway emissions, the number of calls (by vessel type and DWT range) had to be allocated to each port. The ports in Delaware include the Port of Wilmington, Magellan Terminal, Delaware City Refinery, and Oceanport. One port in New Jersey, Bermuda

International on Salem Creek, is located adjacent to Delaware. All other ports in New Jersey and all ports in Pennsylvania are located north of the Delaware/Pennsylvania state line. Vessels calling on New Jersey and Pennsylvania ports must be included in underway emission calculations for Delaware since the vessels travel through the Delaware portion of the bay and river.

Table 4-19 presents the assigned propulsion engine power and the number of calls by vessel type, DWT range and engine type for calls on the Delaware River area in 2011. In addition to vessels traveling in the Delaware River Bay and River, 256 OGVs traversed the C&D Canal to or from the Chesapeake Bay.

Table 4-19. Average Propulsion Engine Power and the 2011 Number of Calls for OGVs Calling on the Delaware River Area (DE, NJ and PA)

Code	DWT Range	Engine Type	Power (hp)	Calls	Code	DWT Range	Engine Type	Power (hp)	Calls
BU	< 25,000	2-stroke	9,665	49	RR	<15,000	2-stroke	8,280	7
BU	< 25,000	4-stroke	7,504	8	RR	<15,000	4-stroke	8,553	7
BU	25,000 - 35,000	2-stroke	9,696	64	RR	15,000 - 30,000	2-stroke	12,852	41
BU	35,000 - 45,000	2-stroke	10,320	37	RR	>30,000	2-stroke	26,562	2
BU	> 45,000	2-stroke	16,328	99	TA	<30,000	2-stroke	10,008	40
CC	< 25,000	2-stroke	17,757	159	TA	<30,000	4-stroke	7,077	10
CC	< 25,000	4-stroke	10,898	84	TA	<30,000	Steam	14,646	4
CC	25,000 - 35,000	2-stroke	16,327	185	TA	30,000 - 60,000	2-stroke	12,616	74
CC	35,000 - 45,000	2-stroke	34,467	75	TA	30,000 - 60,000	4-stroke	15,360	5
CC	> 45,000	2-stroke	30,856	160	TA	30,000 - 60,000	Steam	15,498	51
GC	< 15,000	2-stroke	5,784	6	TA	60,000 - 90,000	2-stroke	16,026	65
GC	< 15,000	4-stroke	3,944	7	TA	60,000 - 90,000	4-stroke	14,305	10
GC	15,000 - 30,000	2-stroke	10,456	3	TA	90,000 - 120,000	2-stroke	15,451	172
GC	15,000 - 30,000	4-stroke	7,536	1	TA	90,000 - 120,000	Steam	23,923	4
MS	< 10,000	2-stroke	3,500	16	TA	120,000 - 150,000	2-stroke	23,046	39
MS	< 10,000	4-stroke	11,671	8	TA	> 150,000	2-stroke	25,559	133
PR	< 5,000	4-stroke	16,108	0	TA	> 150,000	Steam	36,324	41
RF	5,000 - 10,000	2-stroke	9,706	118	VE	<12,500	2-stroke	11,877	6
RF	5,000 - 10,000	4-stroke	6,837	20	VE	<12,500	4-stroke	13,150	1
RF	10,000 - 15,000	2-stroke	12,500	190	VE	12,500 - 15,000	2-stroke	12,859	11
RF	10,000 - 15,000	4-stroke	15,672	4	VE	12,500 - 15,000	4-stroke	14,770	2
RF	> 15,000	2-stroke	18,467	9	VE	15,000 - 17,500	2-stroke	13,911	30
					VE	> 17,500	2-stroke	15,224	117

Towboats and Tug Assists

Towboats are used to transport non-self-propelled vessels, either dry cargo or tanker barges, throughout the Delaware River area, including the C&D Canal. DAQ obtained data on the number of towboat trips during calendar year 2011 from *Waterborne Commerce of the United States*. DAQ subtracted the number of towboat trips for the Port of Wilmington (POW) and the C&D Canal from the number of trips on the Delaware River (PA to the Sea). For towboats

traveling to and from the POW and traveling through the C&D Canal, DAQ assumed that half the vessels travel north and the other half travel south to/from the POW and the canal.

In 2011, 4,492 towboat trips transited Delaware waters on the Delaware River, with a trip defined as a one-way passage. 640 towboat trips entered or exited the Port of Wilmington, and 2,332 towboat trips transited the C&D Canal.

Tugs assist OGVs from the shipping channel to its intended berth and then back to the channel when the vessel leaves port. This activity is considered the maneuvering mode for OGVs. Two tugs are typically required to assist an OGV with a DWT greater than 20,000 tons; for smaller OGVs, one tug suffices. The number of tug assists (2,370 in 2011) is directly related to the number of OGVs calling to a Delaware port. Note that a tug assisting a vessel to Bermuda International in New Jersey and the piers at the oil refineries in Marcus Hook, PA will require a tug to pick up the OGV in Delaware waters, thus tug assists are included for these docks. The tug meeting time to the docking time is usually within one hour.

In addition to assisting OGVs to maneuver into port, tugboats escort gas carriers through the Delaware Bay and River. Other vessels typically do not utilize an escort. Tug escort trips are included in the number of towboat trips transiting Delaware waters presented above. DAQ did not estimate emissions from hoteling of towboats and tugs due to lack of activity data.

Vessel speeds, average maneuvering and hoteling time, propulsion and auxiliary engine horsepower ratings, and engine load factors for OGVs, towboats, and tugs were obtained from EPA's *Deep Sea Ports* and *Preparing Port Emission Inventories*. For RSZ mode, time-in-mode for each vessel was calculated based on vessel speeds and waterway segment distances provided in Table 4-17.

Dredging

Maintenance dredging is performed routinely on the Delaware River to keep the channels to their required depths. Dredging involves multiple vessels, including dredges, assist tugs, and generator barges that provide additional power. Estimating emissions from dredging vessel engine activity is time-consuming. Therefore, DAQ developed emissions based on the volume of material dredged during calendar year 2011 rather than engine activity in kilowatt-hours.

DAQ obtained the dredging activity data from both the USACE and from within DNREC. The amount of material dredged by USACE contractors was obtained from the USACE report on dredging contracts awarded for the year 2011. DAQ also contacted the Delaware Division of Soil and Water Conservation to obtain the amount of material dredged by the Division. Table 4-20 presents the estimated amount of material dredged and the type of dredge used. DAQ assumed all the dredging activity is maintenance dredging. New cut dredging results in higher emissions, therefore this assumption may result in lower emission estimates than are actually occurring in the area.

Table 4-20. Material Dredged in Delaware Waters during 2011

Project Location	County	Type of Equipment	Total Material Dredged (cubic yards)
Philadelphia to the Sea	New Castle	Hydraulic Dredge	549,523
Port of Wilmington	New Castle	Hydraulic Dredge	440,525
Premcor Berth Maintenance	New Castle	Hydraulic Dredge	230,000
Philadelphia to the Sea	Sussex	Hydraulic Dredge	142,303
Beachfill – Roosevelt Inlet	Sussex	Hydraulic Dredge	111,000
Coastal Shoreline Protection	Sussex	Hopper	848,000
Lewes & Rehoboth Canal	Sussex	Hydraulic Dredge	32,000

Ferries

The Cape May-Lewes Ferry was identified as the only ferry service in Sussex County. Monthly trip count data for the Cape May-Lewes Ferry was obtained by contacting the Delaware River & Bay Authority. The Cape May-Lewes Ferry made 4,784 one-way trips in 2011.Times for maneuvering and idling at dock were estimated based on cruise time and round trip schedules. For summer weekday activity, DAQ obtained the average number of weekday trips during the months of June, July and August from ferry schedules.

The Three Forts Ferry was identified as the only ferry service in New Castle County. This ferry travels from either Delaware City, DE or Fort Mott, NJ to Fort Delaware located on Pea Patch Island in the Delaware River. Monthly trip count data for the ferry was obtained by contacting the Delaware River & Bay Authority. The Three Forts Ferry made 2,855 one-way trips in 2011. The Delaware River and Bay Authority also provided the engine and time-in-mode data for the Three Forts Ferry.

Spatial Allocation

DAQ developed county allocation factors for CMV activity data based on the location of the activity on the various waterways and length of the waterway segment. In developing county allocation factors, DAQ assumed that from latitude 39°30' to 25 miles beyond the mouth of the Delaware Bay, the activity is split evenly between Delaware and New Jersey since the ship channel roughly corresponds to the boundary between the two states. Above latitude 39°30', all emissions are allocated to Delaware since the entire breadth of the river is under Delaware's jurisdiction. Allocations were developed for each activity mode, since the activity takes place in different areas depending on the mode.

For OGV maneuvering and hoteling modes, the activity is allocated to the county in which the port is located. All large Delaware ports are located in New Castle County. Much of the maneuvering and hoteling activity thus takes place to New Castle County. OGVs will also hotel at one of the several anchorages along the shipping channel. Emissions are estimated for hoteling that takes place at Delaware's anchorages.

For the RSZ mode, county allocation factors were developed for the four ports in Delaware (Port of Wilmington, Magellan Terminal, Oceanport, and Delaware City Refinery), Bermuda International in New Jersey, and from the Pennsylvania-Delaware border to the breakwater (PA/DE to the Sea).

Allocating dredging to each county was based on the river miles in each county, and split between Delaware and New Jersey below latitude 39°30'. While the Three Forts Ferry travels to Fort Mott on the New Jersey side of the Delaware River, at that latitude, Delaware's jurisdictional waters extend the breadth of the river. Therefore, all activity for the Three Forts Ferry was allocated to New Castle County.

Table 4-21. 2011 Commercial Marine Vessel Emissions by County

SCC	Category Description	County	Annual (TPY)			SSWD (TPD)		
			VOC	NO_X	CO	VOC	NO_X	CO
2280002100	Port - Diesel	New Castle	3	122	14	0.01	0.33	0.04
2280002200	Underway - Diesel	New Castle	12	461	62	0.03	1.27	0.17
2280003100	Port – Residual Fuel Oil	New Castle	6	172	16	0.02	0.47	0.04
2280003200	Underway - RFO	New Castle	30	773	70	0.08	2.12	0.19
228000xxxx		**Total: New Castle**	**51**	**1,528**	**161**	**0.14**	**4.19**	**0.44**
2280002100	Port - Diesel	Sussex	2	63	5	< 0.01	0.17	0.01
2280002200	Underway - Diesel	Sussex	8	389	41	0.03	1.17	0.12
2280003100	Port – Residual Fuel Oil	Sussex	4	129	12	0.01	0.35	0.03
2280003200	Underway - RFO	Sussex	27	705	64	0.07	1.93	0.17
228000xxxx		**Total: Sussex**	**41**	**1,285**	**122**	**0.11**	**3.62**	**0.33**

SECTION 5

ON-ROAD MOBILE SOURCES

The 2011 on-road mobile source inventory is an estimate of vehicle emissions based on actual vehicle miles traveled (VMT) on Delaware roadways in 2011 using EPA's Motor Vehicle Emission Simulator (MOVES) model. Vehicles include passenger cars, light-duty trucks, including sport utility vehicles, heavy-duty trucks, buses, and motorcycles. DAQ is utilizing EPA's National Emissions Inventory (NEI), version 1, run of the MOVES model. Due to resource constraints, DAQ has yet to complete final MOVES runs for 2011. However, DAQ has extensively developed Delaware-specific model inputs and has submitted these input files to EPA as part of the Air Emissions Reporting Rule (AERR) requirements. These inputs will be summarized in this section.

The applicable Standard Classification Codes (SCCs) comprising vehicle type, roadway class, and emission process (exhaust, evaporative, brake wear, and tire wear) are shown in Table 5-1. As an example, the SCC applicable to exhaust emissions from a passenger car fueled by gasoline on an urban interstate would be 220100123X, with the "2201001" indicating that the vehicle is a light-duty gasoline vehicle, the "23" indicating the activity is occurring on an urban interstate, and the "X" indicating that the emissions are exhaust emissions.

Table 5-1. SCCs Included in On-road Mobile Inventory

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
1 - 7	2201001	Vehicle type	Light-duty gasoline vehicles (passenger cars)
1 - 7	2201020	Vehicle type	Light-duty gasoline trucks 1 (0-6,000 lb gross vehicle weight rating [GVWR])
1 - 7	2201040	Vehicle type	Light-duty gasoline trucks 2 (6,001-8,500 lb GVWR)
1 - 7	2201070	Vehicle type	Heavy-duty gasoline vehicles (> 8,500 lb GVWR)
1 - 7	2201080	Vehicle type	Motorcycles (gasoline)
1 - 7	2230001	Vehicle type	Light-duty diesel vehicles (passenger cars)
1 - 7	2230060	Vehicle type	Light-duty diesel trucks (0-8,500 lb GVWR)
1 - 7	2230071	Vehicle type	Class 2b heavy-duty diesel vehicles (8,501-10,000 lb GVWR)
1 - 7	2230072	Vehicle type	Class 3, 4, and 5 heavy-duty diesel vehicles (10,001-19,500 lb GVWR)
1 - 7	2230073	Vehicle type	Class 6 and 7 heavy-duty diesel vehicles (19,501-33,000 lb GVWR)
1 - 7	2230074	Vehicle type	Class 8 heavy-duty diesel vehicles (> 33,000 lb GVWR)
1 - 7	2230075	Vehicle type	Diesel buses
8 - 9	11	Roadway type	Rural interstates
8 - 9	13	Roadway type	Rural other principal arterials
8 - 9	15	Roadway type	Rural minor arterials
8 - 9	17	Roadway type	Rural major collectors
8 - 9	19	Roadway type	Rural minor collectors

Continued next page

Table 5-1. continued

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
8 - 9	21	Roadway type	Rural locals
8 - 9	23	Roadway type	Urban interstates
8 - 9	25	Roadway type	Urban other freeways and expressways
8 - 9	27	Roadway type	Urban other principal arterials
8 - 9	29	Roadway type	Urban minor arterials
8 - 9	31	Roadway type	Urban collectors
8 - 9	33	Roadway type	Urban locals
10	X	Emission process	Exhaust
10	V	Emission process	Evaporative
10	B	Emission process	Brake wear
10	T	Emission process	Tire wear

Delaware-specific Input Data for 2011

The 2008 inventory was the first year that DAQ used the MOVES model to develop on-road mobile emissions. The MOBILE6.2 model was used previously. The MOVES model allows for adjustments to a variety of model inputs, and as such, DAQ, with assistance from the Delaware Department of Transportation (DelDOT), puts forth considerable effort in creating a suite of county-specific input data files. The county-specific input data types created for the 2011 inventory include VMT (by vehicle and roadway type), vehicle registration data (vehicle populations and age distributions), average speeds in the form of speed bin fractions (weekday versus weekend and by roadway type), and inspection and maintenance program specifications. Each of these input data sets are discussed separately below. DAQ relies on the MOVES model defaults for fuel parameters (formulations and supply), meteorological data (temperature and relative humidity), ramp fractions, and weekly and daily fractions.

Vehicle Miles Traveled (VMT) Data

The activity data used for developing the on-road emission inventory is VMT. DelDOT provided 2011 VMT data by roadway type for all counties in Delaware. DelDOT is required to submit calendar year VMT data annually to the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS). The VMT is estimated based on data from permanent traffic count stations throughout the county. DelDOT's traffic count program provides daily and seasonal variation data. Additional temporary stations provide shorter-term counts that are expanded with factors derived from appropriate permanent count stations. Counting and expansion activities are consistent with FHWA guidelines. The traffic data submitted to HPMS are considered the most accurate VMT totals for Delaware.

Since the VMT provided by DelDOT is supplied by HPMS roadway type, the task of creating VMT by MOVES road type fractions requires mapping the twelve HPMS road types to the four MOVES road types. The road type allocations for New Castle County and Sussex County for 2011 are provided in Tables 5-2 and 5-3, respectively.

Table 5-2. New Castle County VMT Fractions by Road Type

MOVES Road Type Code	Road Type Description	VMT Fraction by Road Type
2	Rural Restricted Access	0.0000
3	Rural Unrestricted Access	0.1444
4	Urban Restricted Access	0.2940
5	Urban Unrestricted Access	0.5616
Total		**1.00000**

Table 5-3. Sussex County VMT Fractions by Road Type

MOVES Road Type Code	Road Type Description	VMT Fraction by Road Type
2	Rural Restricted Access	0.0000
3	Rural Unrestricted Access	0.6723
4	Urban Restricted Access	0.0000
5	Urban Unrestricted Access	0.3277
Total		**1.0000**

VMT Fractions by Vehicle Type

VMT by vehicle type data are not collected in Delaware, so an alternate procedure was developed using the local registration data in calculating the VMT mixes rather than using the default MOVES VMT distribution by vehicle type. This methodology uses national default MOVES mileage accumulation data in combination with the Delaware county-specific registration data to develop estimates of VMT by vehicle type. The number of vehicles registered in Delaware by model year, vehicle type, fuel type and county was multiplied by the average number of miles accumulated annually by vehicles of the same age, vehicle type and fuel type in the MOBILE6.2 default mileage accumulation database. This provided an estimate of VMT by vehicle age and vehicle type. These VMT estimates were then summed for all years by vehicle type. The total VMT for each vehicle type was divided by the total calculated VMT to give VMT fractions by vehicle type. Tables 5-4 and 5-5 present the resulting VMT fractions by vehicle type for New Castle County and Sussex County, respectively.

Table 5-4. New Castle County VMT Fractions by Vehicle Type

MOVES Vehicle Type Code	Vehicle Description	VMT Fraction by Vehicle Type
11	Motorcycle	0.0073
21	Passenger Car	0.4636

Continued next page

Table 5-4. continued

31	Passenger Truck	0.3669
32	Light Commercial Truck	0.1232
41	Intercity Bus	0.0038
42	Transit Bus	0.0014
43	School Bus	0.0019
51	Refuse Truck	0.0003
52	Single Unit Short-haul Truck	0.0077
53	Single Unit Long-haul Truck	0.0007
54	Motor Home	0.0002
61	Combination Short-haul Truck	0.0115
62	Combination Long-haul Truck	0.0113
Total		**1.0000**

Table 5-5. Sussex County VMT Fractions by Vehicle Type

MOVES Vehicle Type Code	Vehicle Description	VMT Fraction by Vehicle Type
11	Motorcycle	0.0110
21	Passenger Car	0.3670
31	Passenger Truck	0.4242
32	Light Commercial Truck	0.1449
41	Intercity Bus	0.0054
42	Transit Bus	0.0020
43	School Bus	0.0019
51	Refuse Truck	0.0004
52	Single Unit Short-haul Truck	0.0090
53	Single Unit Long-haul Truck	0.0009
54	Motor Home	0.0002
61	Combination Short-haul Truck	0.0164
62	Combination Long-haul Truck	0.0168
Total		**1.0000**

VMT Temporal Allocations

The MOVES model input files include allocations of VMT by month. Monthly allocation of VMT is accomplished through the use of permanent count station data provided by DelDOT. For 2011, DelDOT provided monthly VMT data from 24 permanent count stations throughout New Castle County and 26 in Sussex County. Each month's data for all count stations in a county were summed and divided by the sum of the annual VMT recorded by the all count stations in a county. The monthly VMT fractions created in this way are provided in Tables 5-6 and 5-7.

Table 5-6. Monthly VMT Allocation Fractions for New Castle County

Month	VMT Fraction	Month	VMT Fraction
January	0.0711	July	0.0878
February	0.0759	August	0.0852
March	0.0816	September	0.0860
April	0.0838	October	0.0873
May	0.0856	November	0.0848
June	0.0890	December	0.0818

Table 5-7. Monthly VMT Allocation Fractions for Sussex County

Month	VMT Fraction	Month	VMT Fraction
January	0.0663	July	0.1070
February	0.0715	August	0.0998
March	0.0743	September	0.0874
April	0.0802	October	0.0803
May	0.0882	November	0.0753
June	0.0974	December	0.0725

Vehicle Populations and Age Distributions

Vehicle registration data were obtained from the Delaware Division of Motor Vehicles (DMV). The data are a snapshot of DMV's registration database as of July 1, 2011. The data show the number of vehicles registered by model year for each of the 16 MOBILE6.2 vehicle classes. The 16 vehicle classes were converted to the 13 MOVES vehicle types using a converter provided by EPA. New Castle County and Sussex County vehicle populations by MOVES vehicle type are provided in Tables 5-8 and 5-9, respectively. Vehicle age distribution fractions were developed for each of the 13 vehicle types based on model year. Vehicles 30 years and older were lumped into one fraction.

Table 5-8. 2011 Vehicle Populations for New Castle County

Vehicle Code	Vehicle Type	Number of Vehicles
11	Motorcycle	13,298
21	Passenger Vehicle	228,976
31	Passenger Truck	144,526
32	Light Commercial Truck	47,650
41	Intercity Bus	445
42	Transit Bus	273
43	School Bus	1,001

Continued next page

Table 5-8. continued

51	Refuse Truck	69
52	Single Unit Short-Haul Truck	2,988
53	Single Unit Long-Haul Truck	209
54	Motor Home	373
61	Combination Short-Haul Truck	1,087
62	Combination Long-Haul Truck	818

Table 5-9. 2011 Vehicle Populations for Sussex County

Vehicle Code	Vehicle Type	Number of Vehicles
11	Motorcycle	8,733
21	Passenger Vehicle	82,910
31	Passenger Truck	78,998
32	Light Commercial Truck	26,462
41	Intercity Bus	285
42	Transit Bus	192
43	School Bus	431
51	Refuse Truck	48
52	Single Unit Short-Haul Truck	1,998
53	Single Unit Long-Haul Truck	141
54	Motor Home	217
61	Combination Short-Haul Truck	794
62	Combination Long-Haul Truck	624

Vehicle Speeds

The MOVES model represents average vehicle speeds by roadway type through the use of speed bin fractions. There are 16 speed bins with the first representing speeds less than 2.5 miles per hour (mph), with each subsequent bin having a range of 5 mph (i.e., 42.5 mph – 47.5 mph). The final bin represents speeds equal to or greater than 72.5 mph. For 2011, DelDOT provided seasonal speed bin fractions for each of the four MOVES roadway types, for each hour of the day, and for weekday and weekend driving patterns. DelDOT estimated speeds using the Peninsula travel demand model. The model accounts for traffic volumes and variations in travel according to purpose, which impact average speeds. Table 5-10 summarizes the matrix of parameters that results in 12,288 records for speeds in each county.

Table 5-10. 2011 Average Speed Matrix

Parameter	Number of Variables
Season	4
Hour	24
Roadway Type	4
Weekday/Weekend	2
Speed Bins	16

Inspection and Maintenance (I/M)

The I/M programs for New Castle County include a biennial onboard diagnostic testing program (OBD II) since 2002 for 1996 and later model year vehicles. Vehicle emission computer systems are checked for any diagnostic trouble codes present, a symptom of excess emissions which is a failing result for the vehicle. Older vehicles, starting with model year (MY) 1968, are given a curb idle test (MY 1968-1980) or a two-speed idle test (MY 1981- 1995). A tailpipe probe is inserted for 60 seconds to determine exhaust concentrations of hydrocarbons and carbon monoxide. Depending on the model year, vehicles with an excess emission concentration of either pollutant will fail the test. Older vehicles (MY 1975-1995) are also given a fuel system pressure test (FP) and a gas cap (GC) test. Air pressure is applied to the fuel system from the fuel inlet to the canister. After air pressure has been applied, pressure degradation is monitored. Vehicles fail the fuel system pressure test if it cannot maintain the equivalent pressure of eight inches of water for up to two minutes after being pressurized to 14.0 ± 0.5 inches of water. A similar pressure test is applied to the vehicle's gas cap.

Table 5-11. 2011 New Castle County I/M Program Parameters

Test Type	IDLE	2500/IDLE	FP & GC	OBD I/M Evap	OBD I/M Exh
Test Frequency	Biennial	Biennial	Biennial	Biennial	Biennial
Program Type	Test Only	Test Only	Test Only	Test Only	Test Only
Model Years	1968-1980	1981-1995	1975-1995	1996-2003	1996-2003
Compliance Factors (%)					
Passenger Vehicle	92.46	95.69	96.00	95.68	95.68
Passenger Truck	86.69	88.38	88.86	89.04	87.91
Light Comm. Truck	76.86	78.36	78.78	78.49	74.69
Vehicles Tested (gasoline only)					
Passenger Vehicle	Yes	Yes	Yes	Yes	Yes
Passenger Truck	Yes	Yes	Yes	Yes	Yes
Light Comm. Truck (up to 8,500 GVWR)	Yes	Yes	Yes	Yes	Yes
School Bus	No	No	No	No	No
Single Unit Short-Haul Truck	No	No	No	No	No
Single Unit Long-Haul Truck	No	No	No	No	No
Refuse Truck	No	No	No	No	No
Combination Short-Haul Truck	No	No	No	No	No
Combination Long-Haul Truck	No	No	No	No	No
Motor Home	No	No	No	No	No
Intercity Bus	No	No	No	No	No
Transit Bus	No	No	No	No	No
Motorcycle	No	No	No	No	No

The Sussex County I/M program includes only an idle test.

Table 5-12. 2011Sussex County I/M Program Parameters

Test Type	IDLE
I/M Program Years	1991-2050
Test Frequency	Biennial
Program Type	T/O
Model Years	1981-2005
Compliance Factors (%)	
Passenger Vehicle	94.94
Passenger Truck	88.47
Light Comm. Truck	80.97
Vehicles Tested (gasoline only)	
Passenger Vehicle	Yes
Passenger Truck	Yes
Light Comm. Truck (up to 8,500 GVWR)	Yes
School Bus	No
Single Unit Short-Haul Truck	No
Single Unit Long-Haul Truck	No
Refuse Truck	No
Combination Short-Haul Truck	No
Combination Long-Haul Truck	No
Motor Home	No
Intercity Bus	No
Transit Bus	No
Motorcycle	No

Controls

All MOVES-recognized on-road control measures known to be in place in Delaware in 2011 were included in the MOVES emission inventory mode modeling. Local control programs include Delaware's I/M program, the Federal reformulated gasoline program, and the Northeast Ozone Transport Region LEV program. The MOVES model internally includes all national control programs, such as the Tier 1 and Tier 2 gasoline fuel and light duty engine emission standards as well as the ultra-low sulfur diesel fuel and heavy duty engine standards.

Two Delaware control programs, the anti-tampering procedures (ATP) performed at the inspections lanes and the anti-idling regulation were not accounted for in the MOVES runs since the model does not provide for inputting these programs. For the ATP control program, vehicles that are tested are also checked to see if the catalytic converter, gas cap and fuel inlet restrictor are present. Vehicles will fail inspection if any of these devices are missing.

Regulation 1145, Excessive Idling of Heavy Duty Vehicles, is designed to eliminate emissions caused by extending idling. While MOVES delineates emissions processes for extended idling,

currently the available control programs within MOVES do not account for anti-idling measures. Delaware currently has no off-model method to determine emission benefits from either ATP or Reg. 1145.

Emissions from NEI v1

Table 5-13. 2011 Annual and SSWD Emissions for On-road Mobile Sources by County

	Annual (TPY)			SSWD (TPD)		
County	**VOC**	**NO_x**	**CO**	**VOC**	**NO_x**	**CO**
New Castle	3,285	7,495	37,489	8.85	20.65	91.58
Sussex	2,974	4,702	28,323	8.86	14.87	78.67